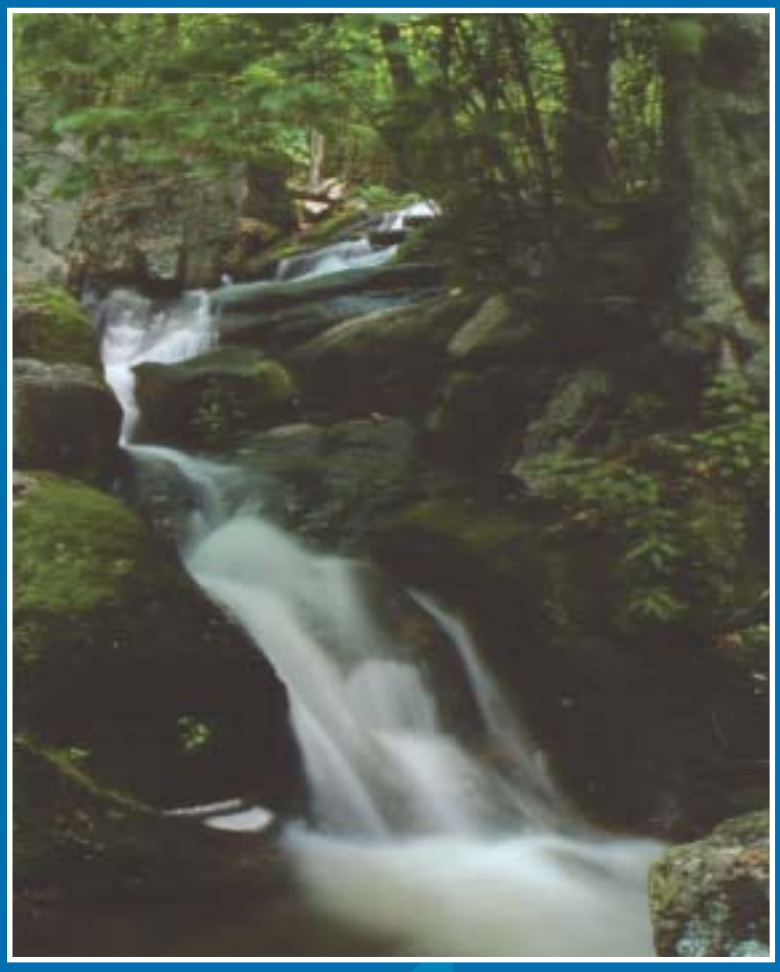
VIRGINIA DEPARTMENT OF FORESTRY

Best Management Practice Field Audits

10 Year Summary Report



December 2003

Virginia Department of Forestry Best Management Practice Field Audits

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INTRODUCTION

In 1988 the Virginia Department of Forestry (VDOF) began a rigorous forestry best management practice (BMP) inspection program. The State Forester's Task Force for Water Quality established an operational goal of inspecting all timber harvests in Virginia that are 5 acres in size or larger. This has resulted in over 40,452 inspections since 1993 when records were centralized in the VDOF information management system database (IMS).

A semi-annual Best Management Practice Field Audit was also initiated in 1993 as a means to accurately document activities in three categories: BMP effort, BMP implementation, and BMP effectiveness. The field audit procedure and method were designed to be statistically rigorous, to facilitate consistency in application and interpretation year-to-year, and to be simple to implement, interpret, communicate, and understand. The procedures, method of data collection, and interpretation of results have not changed over the 10-year interval from 1993 to 2003. This allows meaningful analysis of data and trends. This report summarizes data collected during 17 semi-annual field audits for the period beginning November 1993 and ending June 2003.

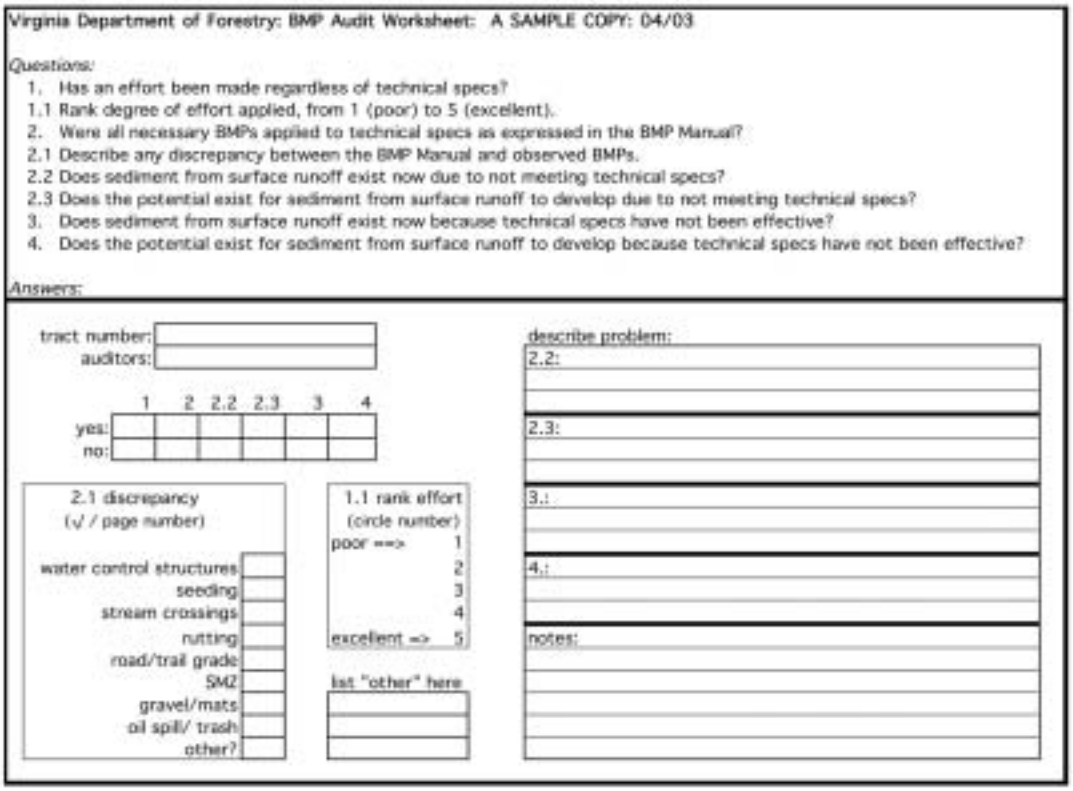
METHODS

The purpose of the Best Management Practice Field Audit is to accurately document BMP effort, BMP implementation, and BMP effectiveness, and any changes in these parameters over time. An important component of the audit is keeping these categories distinct. Doing so provides accurate feedback, identifying specifically to what extent and in which areas of activity failures and successes are found. For example, identifying progress in BMP implementation and, separately, BMP effectiveness, allows the isolation of trends in each category to avoid confusing them. This specific information, consistently and accurately collected, yields information that can improve management decisions.

In June and again in November of each year, 30 sample sites are randomly selected from the timber harvests listed in the VDOF information management system database as having been inspected by VDOF or industry cooperators during the previous six months. These tracts are selected using a random number generator, from final inspections of closed operations made in each of the Virginia Department of Forestry's six regions.

A group of audit team members is assembled and, after site selection, the randomly chosen sites are divided among the group members for inspection. Each group member, alone or with an assigned partner, travels to his or her assigned area to be audited. Local VDOF field personnel may help each group locate its assigned sites. Information is collected at each site using a standard *BMP Effort, Implementation, and Effectiveness Audit Sheet*, shown in Figure 1. The audit sheets are returned to the VDOF forest hydrologist who tabulates, summarizes, and reports the results.

Figure 1: An example of the tally sheet used in all VDOF BMP field audits.



Virginia Department of Forestry: BMP Audit Worksheet: A SAMPLE COPY: 04/03

Questions:

1. Has an effort been made regardless of technical specs?
1.1 Rank degree of effort applied, from 1 (poor) to 5 (excellent).
2. Were all necessary BMPs applied to technical specs as expressed in the BMP Manual?
2.1 Describe any discrepancy between the BMP Manual and observed BMPs.
2.2 Does sediment from surface runoff exist now due to not meeting technical specs?
2.3 Does the potential exist for sediment from surface runoff to develop due to not meeting technical specs?
3. Does sediment from surface runoff exist now because technical specs have not been effective?
4. Does the potential exist for sediment from surface runoff to develop because technical specs have not been effective?

Answers:

tract number:
auditors:

describe problem:
2.2:
2.3:
3.:
4.:
notes:

	1	2	2.2	2.3	3	4
yes:						
no:						

2.1 discrepancy (√ / page number)

water control structures
seeding
stream crossings
rutting
road/trail grade
SMZ
gravel/mats
oil spill/ trash
other?

1.1 rank effort (circle number)

poor ==> 1 2 3 4 excellent => 5

list "other" here

In the field every effort is made to adhere to a consistent observation and data collection methodology. All data recorded on the audit sheet are determined by actual field observations made during the field inspection. Questions in each audit category are designed to prevent ambiguous responses. Questions have remained effectively the same during the 10-year period. Two members of the current audit team, Samuel Austin and Matt Poirot, have participated in each of the 17 field audits. The result is data that are accurate and comparable year-to-year.

RESULTS

BMP Effort

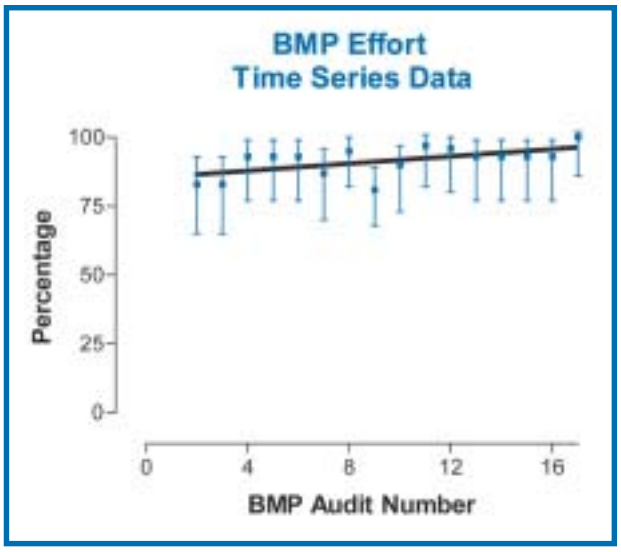
BMP Effort is a measure of the attempt to use best management practices. The question asked is: Has an effort been made to use best management practices regardless of VDOF technical specifications (yes or no)? Any evidence of an attempt to implement one or more best management practices yields a positive evaluation (yes) in this category. It is not necessary to implement a BMP fully or meet VDOF technical criteria in order to receive a positive (yes) evaluation. The State Forester's Task Force suggested the addition of this metric after the November 1993 BMP Field Audit was completed. Consequently, these data were not collected during the first BMP Field Audit.

The table in Figure 2 lists the percentage of sampled timber harvests in each field audit that received a positive evaluation (yes) in the BMP effort category. These data and confidence intervals are plotted on the graph in Figure 2. The black trend line shows that BMP effort has increased over time.[1]

Figure 2: BMP Effort Trend: r^2 = 0.3403, deviation of the regression from 0 slope is significant.

BMP Effort Trend

Date	Percentage	Upper 95% CI	Lower 95% CI
Nov-93	n/a	n/a	n/a
Jun-94	83%	93%	65%
Nov-94	83%	93%	66%
Jun-95	93%	99%	77%
Dec-95	93%	99%	77%
Jun-96	93%	99%	77%
Nov-96	87%	95%	70%
Jun-97	95%	99%	81%
Nov-98	81%	90%	69%
Oct-99	90%	97%	73%
Jun-00	97%	101%	81%
Nov-00	96%	101%	81%
Jul-01	93%	99%	77%
Nov-01	93%	99%	77%
Jun-02	93%	99%	77%
Nov-02	93%	99%	77%
Jun-03	100%	102%	86%



[1] A linear regression of these data yields a positive, upward sloping, trend that is statistically significant, as represented by the black line. This means that the upward slope of the regression line is statistically different from a line with a zero slope.

The quality of BMP effort is also evaluated. At each site, quality of BMP effort is ranked on a scale from 1 (poor) to 5 (excellent). Average values of these figures for individual audits have ranged from 2.5 to 3.3 with an overall average of 2.9. These values are listed in the table and plotted on the graph in Figure 3. The black trend line in Figure 3 is statistically similar to a line with no slope, indicating that over time the average quality of BMP effort has not changed with any statistical significance.[2]

Figure 3: BMP Effort Average Quality Ranking Trend: $r^2 = 0.1687$, deviation of the regression from 0 slope is not significant.

BMP Effort Quality Ranking

Date	Average Quality Ranking 1 = poor, 5 = excellent
Nov-93	n/a
Jun-94	n/a
Nov-94	n/a
Jun-95	3.1
Dec-95	2.9
Jun-96	2.8
Nov-96	2.6
Jun-97	2.6
Nov-98	2.9
Oct-99	2.5
Jun-00	2.7
Nov-00	3.1
Jul-01	2.9
Nov-01	3.3
Jun-02	3.2
Nov-02	2.9
Jun-03	3.1

[2] A linear regression of these data yields a slightly positive upward sloping trend as represented by the black line that in this instance is statistically insignificant. This means that the upward slope of the regression line is no different statistically than a line with a zero slope (a horizontal line).

BMP Implementation

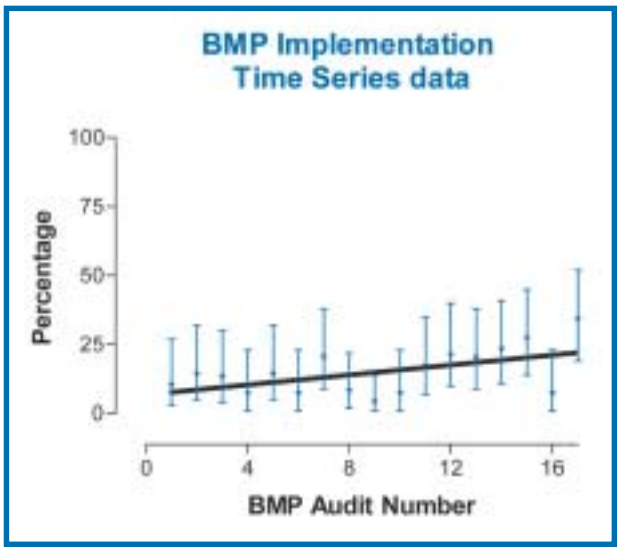
BMP Implementation is a measure of the attempt to implement best management practices to the standards described in VDOF technical guidance. The question asked is: Were all necessary best management practices applied to technical specifications as expressed in the Virginia Department of Forestry BMP manual (yes or no)? Implementation of all necessary best management practices, to the standards described in VDOF technical guidance, yields a positive evaluation (yes) in this category. Only those BMP necessary for the site under consideration need be applied to VDOF standards in order to receive a positive (yes) evaluation.

The table in Figure 4 lists the percentage of sampled sites that received a positive evaluation (yes) in the BMP implementation category. These data and confidence intervals are plotted on the graph in Figure 4. The black trend line shows that BMP implementation has increased over time.[3]

Figure 4: BMP Implementation Trend: $r^2 = 0.2943$, deviation of the regression line from 0 slope is significant.

BMP Implementation Trend

Date	Percentage	Upper 95% CI	Lower 95% CI
Nov-93	10%	27%	3%
Jun-94	14%	32%	5%
Nov-94	13%	30%	5%
Jun-95	7%	23%	1%
Dec-95	14%	32%	5%
Jun-96	7%	23%	1%
Nov-96	20%	38%	9%
Jun-97	8%	22%	2%
Nov-98	4%	13%	0%
Oct-99	7%	23%	1%
Jun-00	17%	35%	7%
Nov-00	21%	40%	10%
Jul-01	20%	38%	9%
Nov-01	23%	41%	12%
Jun-02	27%	45%	14%
Nov-02	7%	23%	1%
Jun-03	34%	53%	20%



[3] A linear regression of these data yields a positive, upward sloping, trend that is statistically significant, as represented by the black line. This means that the slope upward of the regression line is statistically different from a line with a zero slope.

Active Sedimentation

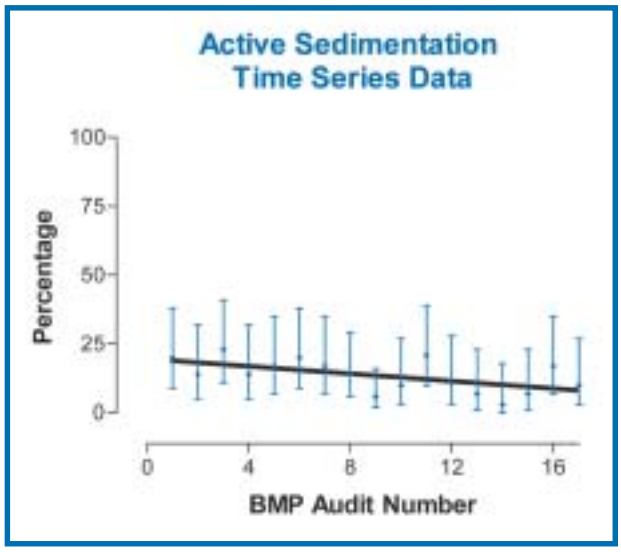
Active Sedimentation is a measure identifying active sediment delivery to a nearby stream or other water body, at the time the field audit is performed, as a consequence of not implementing all necessary BMP to the standards specified by VDOF. The question asked is: Does sedimentation from surface runoff exist now due to not meeting Virginia Department of Forestry technical specifications (yes or no)? Field observation of active erosion tied directly to deposition of soil in a stream or water body yields a positive evaluation (yes) in this category. A continuous pathway such as a rill or gully directly connected to observed delivery of soil to the streambed or water body is needed in order to receive a positive (yes) evaluation. The quantity of sediment delivered is not evaluated, only evidence that the process is active.

The table in Figure 5 lists the percentage of sampled sites that received a positive evaluation (yes) in the active sedimentation category. These data and confidence intervals are plotted on the graph in Figure 5. The black trend line shows that active sedimentation has decreased over time.[4]

Figure 5: Active Sedimentation Trend: $r^2 = 0.3321$, deviation of the regression line from 0 slope is significant**.**

Active Sedimentation Trend

Date	Percentage	Upper 95% CI	Lower 95% CI
Nov-93	20%	38%	9%
Jun-94	14%	31%	5%
Nov-94	23%	41%	12%
Jun-95	14%	31%	5%
Dec-95	17%	35%	7%
Jun-96	20%	38%	9%
Nov-96	17%	34%	7%
Jun-97	14%	29%	6%
Nov-98	6%	16%	1%
Oct-99	10%	27%	3%
Jun-00	21%	39%	10%
Nov-00	11%	28%	3%
Jul-01	7%	23%	1%
Nov-01	3%	18%	0%
Jun-02	7%	23%	1%
Nov-02	17%	34%	7%
Jun-03	10%	27%	3%



[4] A linear regression of these data yields a negative, downward sloping, trend that is statistically significant, as represented by the black line. This means that the downward slope of the regression line is statistically different from a line with a zero slope.

BMP Effectiveness In Limiting Active Sedimentation

Active sedimentation is further quantified with a second question: Does sedimentation from surface runoff exist now because technical specifications have not been effective? This question deals directly with BMP effectiveness. BMP must be fully implemented to the standards specified in VDOF technical guidance *and* active erosion tied directly to deposition of soil in a stream or water body must be observed in order to receive a positive (yes) evaluation. To date 0.7 percent of audited tracts have received a positive evaluation (yes) in this category. This is a clear indication that active sedimentation is negligible when best management practices meet technical specifications.

Potential Sedimentation

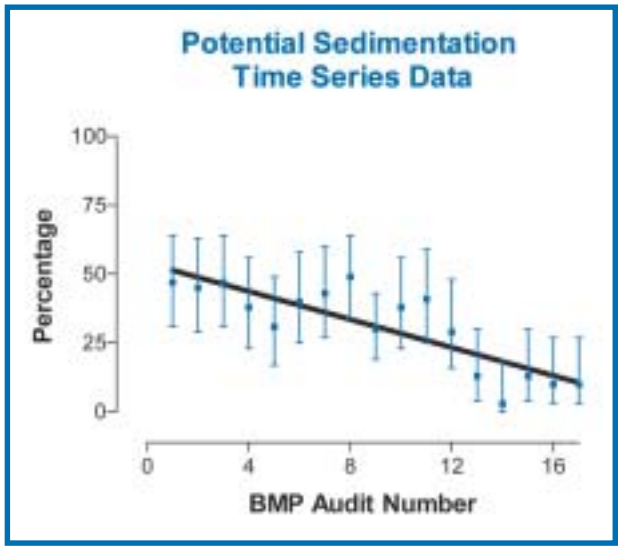
Potential Sedimentation is a measure identifying conditions likely to initiate sediment delivery to a nearby stream or other water body, as a consequence of not implementing all necessary BMP to the standards specified by VDOF. The question asked is: Does the potential exist for sediment from surface runoff to develop due to not meeting Virginia Department of Forestry technical specifications (yes or no)? Field observation of exposed soil adjacent to a stream or water body and other indicators suggesting erosion and sediment deposition are imminent yields a positive evaluation (yes) in this category. Observed field conditions such as inadequate BMP near a water body, exposed mineral soil or erosion adjacent to a water body, are needed in order to receive a positive (yes) evaluation. The quantity of potential sediment is not evaluated, only evidence that landscape conditions are conducive to initiating the process if rainfall occurs.

The table in Figure 6 lists the percentage of sites that received a positive evaluation (yes) in the potential sedimentation category. These data and confidence intervals are plotted on the graph in Figure 6. The black trend line shows that potential sedimentation has decreased over time.[5]

Figure 6: Potential Sedimentation Trend: $r^2 = 0.7024$, deviation of the regression line from 0 slope is significant**.**

Potential Sedimentation Trend

Date	Percentage	Upper 95% CI	Lower 95% CI
Nov-93	47%	64%	30%
Jun-94	45%	62%	28%
Nov-94	47%	64%	30%
Jun-95	38%	56%	23%
Dec-95	31%	49%	17%
Jun-96	40%	58%	25%
Nov-96	43%	61%	27%
Jun-97	49%	64%	33%
Nov-98	30%	43%	19%
Oct-99	38%	56%	23%
Jun-00	41%	59%	26%
Nov-00	29%	47%	15%
Jul-01	13%	30%	5%
Nov-01	3%	18%	0%
Jun-02	13%	30%	5%
Nov-02	10%	27%	3%
Jun-03	10%	27%	3%



[5] A linear regression of these data yields a negative, downward sloping, trend that is statistically significant, as represented by the black line. This means that the downward slope of the regression line is statistically different from a line with a zero slope.

BMP Effectiveness In Limiting Potential Sedimentation

Potential sedimentation is further quantified with a second question: Does the potential exist for sediment from surface runoff to develop because technical specifications have not been effective? This question deals again with BMP effectiveness. BMP must be fully implemented to the standards specified in VDOF technical guidance *and* field conditions must be observed indicating that erosion and sediment deposition are imminent in order to receive a positive evaluation (yes) in this category. To date 2.8 percent of audited tracts have received a positive evaluation (yes) in this category. This is a clear signal that potential sedimentation is minimal when best management practices meet technical specifications.

DISCUSSION

Percentages computed from the data collected in each audit have varied year to year. Now however, with data in hand spanning 10 years of measurements, statistically significant trends have emerged. This suggests that a consistent and straightforward method of measurement and evaluation, applied to distinct BMP categories and documented design criteria, can yield accurate information and trends over time that are useful to management decision making.

CONCLUSION

The VDOF Best Management Practice Field Audits have, and continue to provide, accurate documentation of BMP effort, BMP implementation, and BMP effectiveness, and changes in these parameters over time. The audit results reflect the large scope of work, commitment and high standards expressed in the goals of the Virginia Department of Forestry water quality program.

APPENDIX: STATISTICAL METHODS

Determining Confidence Intervals

The 95% confidence interval for each (yes/no) question in the BMP field audit is computed using the Wald equation. This equation is well suited to data that have two possible outcomes, such as "yes" or "no," and that can be represented in a proportion. Additional discussion of the Wald equation can be found in "The American Statistician, 52: 119-126, 1998. The equation is shown in Figure 7.

Figure 7: Wald equation.

$$\left[p' - \left(1.96\sqrt{\frac{p'(1-p')}{N+4}}\right)\right] \text{ to } \left[p' + \left(1.96\sqrt{\frac{p'(1-p')}{N+4}}\right)\right]$$

$$\text{where: } p' = \frac{\#\text{ "successes"} + 2}{\#\text{ of experiments} + 4} = \frac{S+2}{N+4}$$

Applying the Wald equation yields statistics in each category of interest, BMP Effort, BMP Implementation, Active Sedimentation, Potential Sedimentation, and BMP Effectiveness. These values are shown in Figures 2, 4, 5, and 6 for each audit completed to date. These are the same values shown as confidence interval "error bars" in the trend graphs.

Determining Trends

A simple linear regression is performed on the data in each category to determine if we have observed a statistically significant trend over time. If the slope of the regression line is statistically different from a zero slope, then a statistically significant trend is thought to exist. Linear regression of the BMP Effort, BMP Implementation, Active Sedimentation, and Potential Sedimentation datasets, results in a statistically significant trend in each. In each instance the slope of the regression line is significantly different from zero, as indicated in the trend analysis summaries shown in Tables 1 through 4.

Table 1: BMP Effort Trend Analysis.

Best-fit values	
Slope	0.6544 ± 0.2435
Y-intercept	85.22 ± 2.572
X-intercept	-130.2
1/slope	1.528
95% Confidence Intervals	
Slope	0.1320 to 1.177
Y-intercept when X=0.0	79.70 to 90.74
X-intercept when Y=0.0	-683.2 to -68.14
Goodness of Fit	
r squared	0.3403
Sy.x	4.491
Is slope significantly non-zero?	
F	7.220
DFn, DFd	1.000, 14.00
P value	0.0177
Deviation from zero?	Significant

Table 2: BMP Implementation Trend Analysis.

Best-fit values	
Slope	0.8971 ± 0.3587
Y-intercept	6.809 ± 3.676
X-intercept	-7.590
1/slope	1.115
95% Confidence Intervals	
Slope	0.1327 to 1.661
Y-intercept when X=0.0	-1.024 to 14.64
X-intercept when Y=0.0	-103.8 to 0.6553
Goodness of Fit	
r squared	0.2943
Sy.x	7.245
Is slope significantly non-zero?	
F	6.254
DFn, DFd	1.000, 15.00
P value	0.0245
Deviation from zero?	Significant

Table 3: Active Sedimentation Trend Analysis.

Best-fit values	
Slope	-0.6691 ± 0.2450
Y-intercept	19.61 ± 2.511
X-intercept	29.31
1/slope	-1.495
95% Confidence Intervals	
Slope	-1.191 to -0.1470
Y-intercept when X=0.0	14.26 to 24.96
X-intercept when Y=0.0	19.95 to 101.9
Goodness of Fit	
r squared	0.3321
Sy.x	4.949
Is slope significantly non-zero?	
F	7.457
DFn, DFd	1.000, 15.00
P value	0.0155
Deviation from zero?	Significant

Table 4: Potential Sedimentation Trend Analysis.

Best-fit values	
Slope	-2.549 ± 0.4284
Y-intercept	53.94 ± 4.389
X-intercept	21.16
1/slope	-0.3923
95% Confidence Intervals	
Slope	-3.462 to -1.636
Y-intercept when X=0.0	44.59 to 63.30
X-intercept when Y=0.0	17.61 to 28.29
Goodness of Fit	
r squared	0.7024
Sy.x	8.653
Is slope significantly non-zero?	
F	35.41
DFn, DFd	1.000, 15.00
P value	< 0.0001
Deviation from zero?	Significant

Identifying the Extent of Departure from Technical Standards

Best management practices may be organized into nine major categories. These are: stream crossings, water control structures, seeding/vegetative cover, stream side management zones, trail/road grade, rutting, gravel/mats, oil spill/trash, and other.

Identifying the number of major BMP categories that fall short of full compliance with technical guidance provides additional insight into change over time. Table 5 lists this information showing the percentage of tracts in each field audit organized by the number of necessary BMP categories that fall short of full compliance with BMP technical standards. These percentages are not related to the figures presented in the body of the report. They offer a supplementary indication of the *extent* of departure from technical standards. Less than full compliance may be identified in zero (0) to nine (9) BMP categories as shown at the top of Table 5. Figures in the left-most column of percentages in Table 5, showing non-compliance in the zero (0) category, indicate the percentage of tracts in full compliance with all necessary best management practices.[6]

For example, in June 2003, 34 percent of surveyed sites were in full compliance with all necessary best management practices. Also in June 2003, 7 percent of surveyed sites had 4 necessary major BMP categories that did not fully meet the standards identified in best management practice technical guidance.

Table 5: Percent of Sites In Less Than Full Compliance Organized by Number of BMP Categories.[6]

The BMP categories are: stream crossings, water control structures, seeding/vegetative cover, stream side management zones, trail/road grade, rutting, gravel/mats, oil spill/trash, and other.

		Number of BMP Categories Not in Compliance									
Audit Date	Number of Tracts Inspected	0	1	2	3	4	5	6	7	8	9
Nov-93	30	10%	3%	23%	20%	20%	23%	0%	0%	0%	0%
Jun-94	29	14%	14%	14%	14%	28%	10%	7%	0%	0%	0%
Nov-94	30	13%	17%	7%	10%	27%	10%	10%	7%	0%	0%
Jun-95	30	7%	20%	10%	23%	17%	13%	10%	0%	0%	0%
Dec-95	29	14%	3%	17%	31%	10%	10%	10%	3%	0%	0%
Jun-96	30	7%	13%	23%	23%	13%	13%	3%	3%	0%	0%
Nov-96	30	20%	10%	13%	40%	3%	10%	3%	0%	0%	0%
Jun-97	37	8%	19%	8%	22%	11%	16%	14%	3%	0%	0%
Nov-98	55	4%	9%	40%	27%	9%	9%	2%	0%	0%	0%
Oct-99	29	7%	10%	21%	34%	21%	3%	3%	0%	0%	0%
Jun-00	29	17%	3%	17%	28%	21%	14%	0%	0%	0%	0%
Nov-00	30	17%	7%	20%	33%	13%	10%	0%	0%	0%	0%
Jun-01	30	20%	17%	17%	20%	23%	3%	0%	0%	0%	0%
Nov-01	30	23%	20%	33%	13%	7%	3%	0%	0%	0%	0%
Jun-02	30	27%	21%	10%	24%	3%	14%	0%	0%	0%	0%
Nov-02	30	7%	27%	20%	23%	13%	10%	0%	0%	0%	0%
Jun-03	30	34%	13%	23%	20%	7%	0%	3%	0%	0%	0%
Total Inspections:	538										
	Average of All Inspections:	15%	13%	19%	24%	14%	10%	4%	1%	0%	0%

[6] The mix of BMP categories comprising each percentage is not identified.

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